DOCUMENT RESUME

ED 470 866 SE 066 811

AUTHOR	Thomas, Gill; Tagg, Andrew; Ward, Jenny
TITLE	Making a Difference: The Early Numeracy Project.
SPONS AGENCY	Ministry of Education, Wellington (New Zealand).
PUB DATE	2002-07-00
NOTE	10p.; In: Mathematics Education in the South Pacific. Proceedings of the Annual Conference of the Mathematics Education Research Group of Australasia Incorporated (25th, Auckland, New Zealand, July 7-10, 2002). Volume I [and] Volume II; see SE 066 808.
PUB TYPE	Reports - Research (143) -- Speeches/Meeting Papers (150)
EDRS PRICE	EDRS Price MF01 Plus Postage. PC Not Available from EDRS
DESCRIPTORS	Concept Formation; Educational Policy; Elementary Secondary Education; Foreign Countries; *Mathematics Education; *Numeracy; Program Descriptions; Teaching Methods
IDENTIFIERS	New Zealand

ABSTRACT

The Numeracy Development Project (New Zealand), now into its third year of implementation, spans years 1 to 10 of schools. By the conclusion of 2001, the project had involved approximately 3,300 teachers and 64,000 students. The Number Framework forms the core of the project program by providing teachers with a knowledge of how students acquire number concepts, an increased understanding of how they can assist students' progress and an effective means to assess students' levels of thinking in number. This paper focuses on the impact that the project has had on the students in the first three years of school and their teachers. (Contains 19 references.) (Author/MM)

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Making a Difference: The Early Numeracy Project

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The Numeracy Development Project (New Zealand), now into its third year of implementation, spans years 1 to 10 of schools. By the conclusion of 2001 the project had involved approximately 3300 teachers and 64000 students. The Number Framework forms the core of the project programme by providing teachers with a knowledge of how students acquire number concepts, an increased understanding of how they can assist students' progress and an effective means to assess students' levels of thinking in number. This paper focuses on the impact that the project has had on the students in the first three years of school and their teachers.

Background

The Numeracy Development Project is positioned within the context of the Ministry of Education's Literacy and Numeracy strategy and reflects the key themes of that strategy: clarifying expectations, improving professional capability and involving the community. The focus of the project is "improving student performance in mathematics through improving the professional capability of teachers" (Ministry of Education, 2002, p i).

In light of the view that professional development programmes can improve outcomes for students, much work has gone into identifying key elements of effective programmes (for example, Clarke & Cheeseman, 2000; Fullan and Hargreaves, 1992; Stephens, 2000). In a review that links professional development programmes with improved teacher capability, Parsons (2001) identifies the following as characteristics of quality programmes:

- the systematic identification of needs;
- a focus on the real world of the classroom, that is, the dynamic of the learner, content knowledge, assessment and pedagogy;
- links to the gathering, analysis and use of high quality assessment data and school development initiatives;
- opportunities for modeling, observation, coaching, critique and reflection, and the use of action research approaches;
- a school based approach over time that fosters collaboration and collegial support;
- effective facilitation, and ongoing guidance and support from within and outside the school;
- the involvement and commitment of school leadership;
- connection with the school and wider community;
- rigorous evaluation based on both quantitative and qualitative data which provides evidence of the impact of professional development on student achievement, teachers' knowledge, beliefs and expectation (Parsons, 2001, p 15).

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B. Barton, K. C. Irwin, M. Pfannkuch, & M. O. J. Thomas (Eds.) *Mathematics Education in the South Pacific* (Proceedings of the 25th annual conference of the Mathematics Education Research Group of Australasia, Auckland, pp. 49-57). Sydney: MERGA. ©2002 MERGA Inc.

These findings are in line with the current professional development policies of the Ministry of Education. The evaluation reports prepared for the Ministry of Education by Higgins (2001) and Thomas and Ward (2001) reinforced the significance of these characteristics in the Numeracy Development Project.

Parallel to the work involved in identifying key factors of effective professional development programmes is a body of research that aims to identify the teaching practices of effective teachers of numeracy. An important project in this area was conducted by King's College London (Askew et al, 1997). It explored the knowledge and beliefs that underpinned the practices of effective teachers and found that what distinguished highly effective teachers from other teachers was a set of beliefs that formed the basis of a particular series of classroom practices. These concerned what it means to be numerate, the relationship between teaching and students' learning of numeracy, and which presentation and intervention strategies are effective. In addition to a well-developed set of beliefs, the "highly effective teachers of numeracy themselves had knowledge and awareness of conceptual connections between the areas which they taught in the primary mathematics curriculum" (Askew et al, 1997, p3).

A feature of the Numeracy Development Project is its evolutionary approach to implementation that reflects an ongoing commitment to develop understanding about how students learn number and what constitutes effective professional development and effective facilitation. In 2001 the Numeracy Development Project was managed as three projects, which spanned years 1 to 10 of schooling. This paper reports on the impact of the Early Numeracy Project (ENP), which focuses on students in the first three years of school, and followed the successful implementation of the Count Me in Too (CMIT) pilot project in 2000. The ENP involved approximately 40 facilitators, 450 schools, 2000 teachers and 39,000 students.

The Number Framework (New Zealand)

Research into children's understanding of number over the last decade suggests that there are identifiable progressions in how children develop number concepts (Carpenter et al, 1999; Clarke et al, 2001; Cobb et al, 1997; Fuson et al, 1997; Jones et al, 1996; Steffe, 1992; Steffe et al, 1983; Wright, 1998; Young-Loveridge, 1999). These progressions have led to the development of models, or frameworks, of early number development that can be viewed as providing useful pedagogical frameworks for teachers. This is based on the assumption that if teachers can identify where a child is on a framework, and can then identify the next step for the child, then teaching should be more effective.

The Number Framework used in the ENP 2001, was developed from the Learning Framework for Number, used in the CMIT Pilot Project. The Number Framework formed the core of the professional development by providing teachers with:

- an effective means to assess students' current levels of thinking in number;
- guidance for instruction;
- knowledge of how children acquire number concepts and an increased understanding of how they can assist children to progress.
  (Ministry of Education, February 2001a)

The Number Framework[1] contains two main sections: strategy and knowledge. The strategy section looks at how students solve number problems, focusing on the mental processes they employ. Nine different strategy stages are described, with increasing levels of sophistication. The nine stages fit within two broader bands: counting and part-whole. It is important to note that the stages on the framework are "big" ideas and that much learning goes on in between each one. It has also become evident that the stages on the framework are not equally spaced. The knowledge section outlines the key aspects of knowledge children need to acquire and has been categorised into; numeral identification, number sequence and order, grouping/place value, basic facts, and written recording. The two sections of strategy and knowledge are seen as dependent on one another, with students needing to make progress in both areas simultaneously.

The Early Numeracy Project Assessment[2] (ENPA), the diagnostic tool used on ENP 2001, was designed to give teachers quality information about the knowledge and strategies of their students, as aligned to the Number Framework. Having teachers assess and monitor the development of children through one-to-one interviews was an integral component of the ENP. The ENPA tool enabled the teachers to develop a number profile for each student. This profile had five components:

- The Stages of Early Arithmetic Learning (SEAL). This related to the students' level of sophistication in counting and other strategies to solve addition and subtraction problems.
- Facility with forward number word sequences (FNWS).
- Facility with backward number word sequences (BNWS).
- Ability to identify numerals (NID)
- Understanding of the place value nature of the number system (BTS)

Teachers used the initial and subsequent assessment to make decisions regarding learning experiences necessary for individual children and groups of children.

Feedback from Participating Teachers

The evidence drawn for this section was gathered from questionnaires sent to 246 teachers in 50 randomly selected participating schools. One hundred and forty-eight questionnaires (60%) were returned. The questionnaires had two components: one aimed at collecting demographic data and the other asking a series of open-ended questions. Responses to the open ended questions were analysed for key themes and patterns. In general, responses fell into three broad areas: feelings about the project, perceived impacts of the project and issues with specific elements of the project.

The teachers were very positive about the project and the impact that it had on their teaching of maths. Ninety-six percent of the teachers believed that their knowledge of how children learn maths had been developed as a result of their participation. They link this increase in knowledge to the belief that they were now more effective in their teaching with

[1] A detailed description of The Number Framework can be viewed at: http://www.nzmaths.co.nz/Numeracy/Numeracy_PDFs/numfwork.pdf

[2] A detailed description of the Numeracy Project Assessment can be viewed at: http://www.nzmaths.co.nz/Numeracy/Numeracy_PDFs/diagint.pdf. This asessment tool has been developed from the ENPA 2001 and the Advanced Numeracy Project Assessment (ANPA) 2001.

92% noting changes in the way they teach number. This belief is summarised in the following quote from one of the teachers.

> I must have been very vague before [the ENP] but now I know how to recognise, promote and teach to strategies. I feel I am much more focused in my teaching objectives...The children are getting a much better deal now in my class and that shows in their progress.

There were several common themes in the changes that teachers reported they had made in their classrooms:

- Increased focus on both number strategies and knowledge linked to The Number Framework.
- More effective assessment and grouping of children.
- Increased emphasis on listening to children and encouraging them to explain their thinking.
- More opportunities for children to share their strategies with others.
- More focused expectations of the progress that children will make.

The most consistent issue that teachers had with the project was related to the resource folder and classroom. Forty-four percent of the teachers felt that too much time was spent making classroom resources and 62% suggested that the layout of the resource folder was confusing.

Student Achievement

Arguably the most important aspect of the Early Numeracy Development Project was its impact on the numerical development of the participating children. As indicated in the previous section most of the teachers believed that their students made significant improvements. This section examines the results of students in Phase One schools. These are the schools which participated in the ENP during terms 1-3 and had submitted final ENPA results by October 12, 2001.

Student progress on the Number Framework was impressive. There was strong positive growth in the five aspects of number learning assessed, irrespective of the students' gender, age, ethnicity or the school's region or decile. Although there was no assigned reference or control group, the profile of students at the start of the project provides a degree of control when compared with the profile of students of the same age at the end of the project. Figure 1 compares the growth that occurred, in each aspect, over the six-month duration of the project with the growth that would have been expected with time alone. As is clearly shown, the gains made on each aspect of number learning during the project exceeded the gains that would have been expected in the students' previous classroom programmes by between 0.7 and 1.2 stages. Overall, the trend was for students to make gains of approximately one stage on each of the five aspects assessed. With the exception of Base 10 strategies, which had a mean gain of 0.8 of a stage, the mean gains for the aspects assessed are between 1.1 and 1.4 stages.

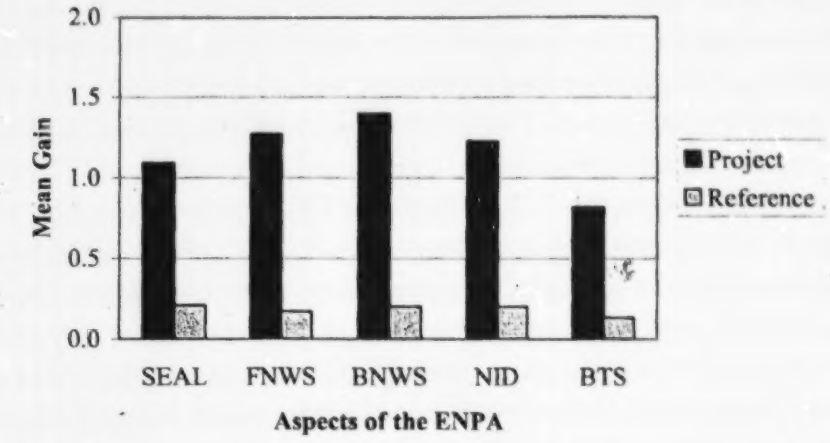

Figure 1. Mean gains by all students.

The size of the gains made was strongly linked to the students' starting points on the Number Framework. Figure 2 links the mean gains made on the SEAL to the initial SEAL stage of the students. As clearly illustrated, the gains are greatest for the lower SEAL stages, which reinforces the notion that the stages are not equally spaced and that the earlier stages are indeed "smaller" or easier to progress through. Students assessed as emergent at the initial assessment made mean gains of 1.56, compared to 0.33 for students assessed initially as early additive. It is interesting to note that older students make greater gains than the younger students regardless of starting stage.

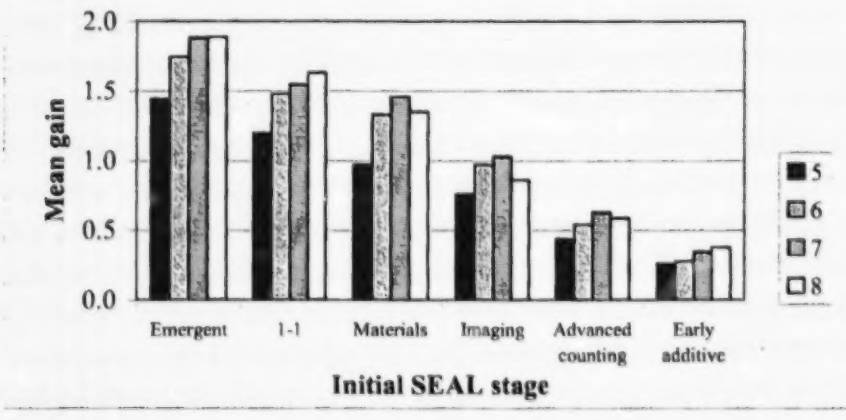

Figure 2. Mean gains on the SEAL linked to initial stage and age.

Figure 3 presents the initial and final breakdown of SEAL scores as a cumulative frequency distribution and clearly shows a decrease in the percentage of students at the lower stages and a corresponding increase in those at the higher stages. At the time of the initial interview, 7% of the students were part-whole (early or advanced additive) in their use of number strategies. By the end of the project this had increased to 23% and, as

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expected, the majority of these students were the seven and eight-year-olds. Correspondingly, the percentage of students who were assessed as emergent had decreased from 14% to 2% over the duration of the project.

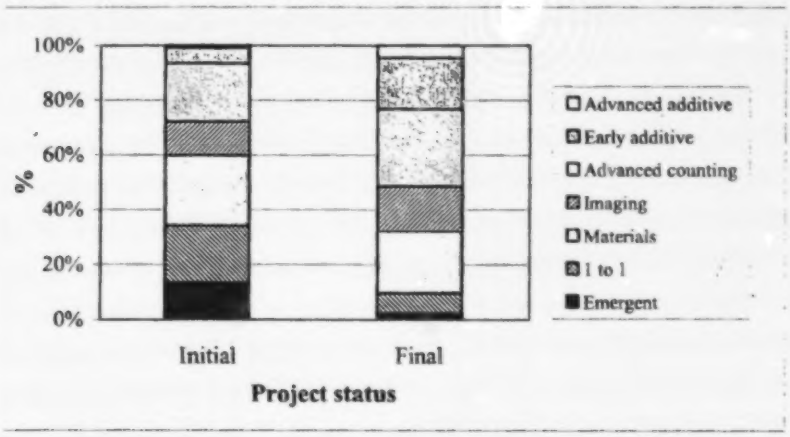

Figure 3. Percentage of students at each SEAL stage by project status.

The remainder of this section examines the performance of students when grouped by ethnicity with a particular focus on the transition from counting to part-whole strategies. The transition to part-whole strategies has been identified by researchers and educators as being critical to success in mathematics (Clarke & Cheeseman, 2000, Wright, 1998; Young-Loveridge, 1999). Figure 4 illustrates the gains made on the SEAL when linked to ethnic group and initial SEAL stage. The gains made by Māori and Pacific Islands students are slightly but consistently lower than the other groups.

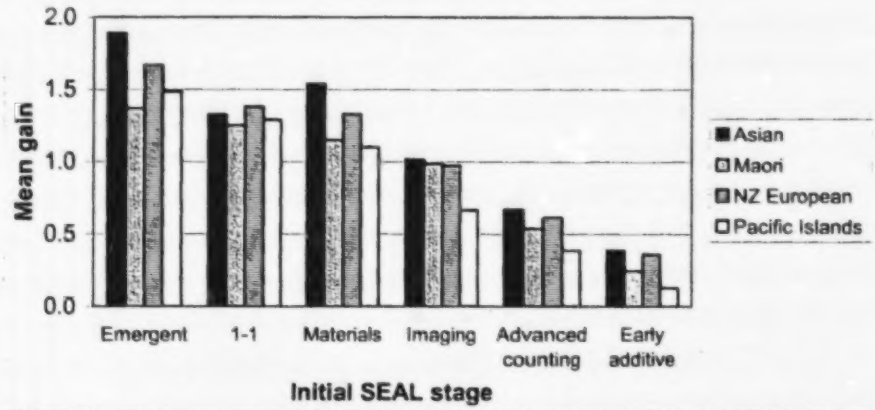

Figure 4. Mean gains on the SEAL linked to initial stage and ethnicity.

The most concerning difference is in the proportions of students who make the transition from advanced counting to part-whole strategies. Figure 5 illustrates the final SEAL stage of students who had an initial SEAL assessment of advanced counting. Just 36% of the Pacific Islands students made the transition to early additive or advanced

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additive compared to 49% of the Māori students, 57% of the NZ European students, and 58% of the Asian students. A higher proportion of Asian students (9%) moved the two stages from advanced counting to advanced additive than any other ethnicity. Pacific Islands students were again poorly represented with only 2% moving two stages.

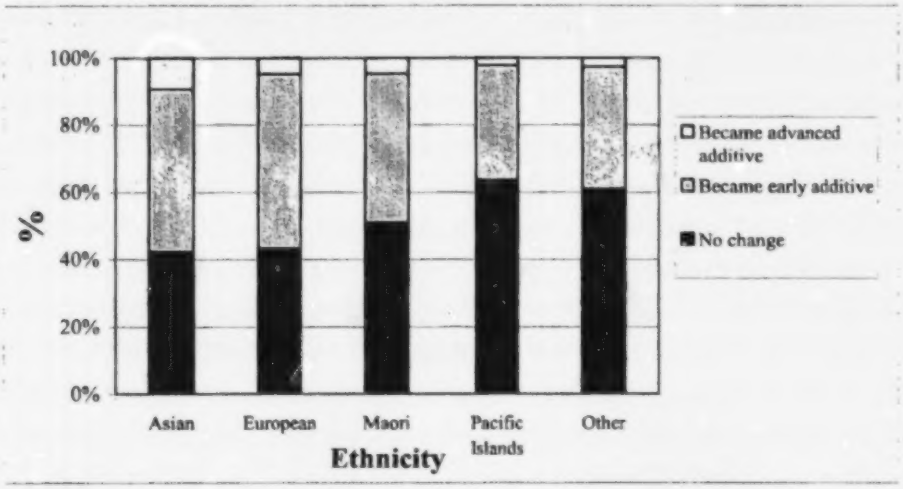

Figure 5. Final SEAL status of students who were initially advanced counters by ethnicity.

Figure 6 compares the mean SEAL scores by ethnicity of the students in the ENP with a sample of 1741 students from 22 schools that were in the CMIT pilot project, and have now participated in the numeracy project for two years.

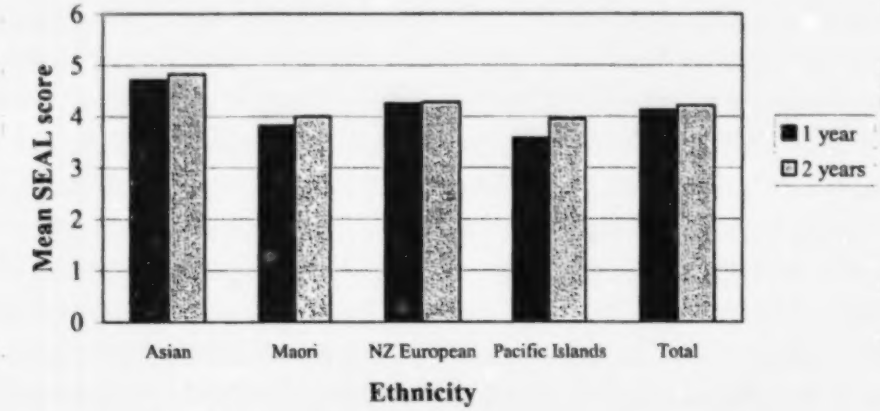

Figure 6. Mean SEAL score by ethnicity and years in project.

Students from schools with two years involvement have slightly higher means across all ethnic groups. The Pacific Islands students have the greatest difference with a mean SEAL score 0.37 of a stage higher in the schools which have participated for two years.

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Given the importance of improved education outcomes for all students it is critical that further refinements of the project continue to focus on improving the outcomes for underachieving students.

Concluding Comments

The most consistent view about the Numeracy Project expressed both formally and informally, is that it empowers teachers and benefits students. Consequently there is a feeling of optimism in participating schools about improved mathematical outcomes for students. Positive publicity associated with the project has increased awareness and demand to the extent that there is a long queue forming as other schools wait for their turn to participate.

Acknowledgments

The Numeracy Development Project is a New Zealand Ministry of Education initiative. We gratefully acknowledge the support of the Ministry of Education for the research projects that have accompanied the Numeracy Development Project. The opinions expressed in this paper are the authors' own and not necessarily those of the Ministry..

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